

CLAIMS

1. A method comprising:

providing a polymerized sol-gel material (PSG); and
linking an enzyme to a surface of the PSG via covalent linkage.

2. The method of claim 1 wherein the providing comprises providing the PSG in a device selected from a group consisting of a column, a pipet, a well, and a well plate.

3. The method of claim 2, wherein the device is sufficient to separate an analyte from a sample.

4. The method of claim 1, wherein the providing comprises providing a PSG that comprises a photopolymerized sol-gel material.

5. The method of claim 1, wherein the providing comprises providing an inorganic PSG.

6. The method of claim 1, wherein the providing comprises providing an inorganic-organic PSG.

7. The method of claim 1, wherein the providing comprises providing a PSG prepared from a metalorganic material.

8. The method of claim 7, wherein the metalorganic material is a metal alkoxide.

9. The method of claim 1, wherein the providing comprises providing a PSG prepared from a photoactive material selected from a group consisting of a metalorganic material that comprises a photoactive group, an organic material that comprises a photoactive group, a photoinitiator, and any combination thereof.

10. The method of claim 1, wherein the providing comprises providing a PSG prepared from a porogen material.

11. The method of claim 1, wherein the providing comprises providing a PSG having at least one pore having a diameter in a range of about 0.5 microns to about 20 microns.

12. The method of claim 1, wherein the linking comprises derivatizing the surface of the PSG with a linker.

13. The method of claim 12, wherein the linker comprises a functional group that facilitates the linking of the linker to the surface of the PSG.

14. The method of claim 13, wherein the functional group is an alkoxy group.

15. The method of claim 12, wherein the linker comprises a functional group that facilitates the linking of the enzyme to the linker.

16. The method of claim 15, wherein the functional group is selected from a group consisting of an aldehyde functional group and a succinimide functional group.

17. The method of claim 12, wherein the linker comprises a silicate material.

18. The method of claim 12, wherein the linker comprises a trialkoxysilane.

19. The method of claim 12, wherein the derivatizing is selected from a group consisting of allowing a solution comprising the linker to flow relative to the PSG, pumping a solution comprising the linker relative to the PSG, placing the PSG in a solution comprising the linker, and any combination thereof.

20. The method of claim 12, wherein the derivatizing is for a time of from about 30 minutes to about 60 minutes.

21. The method of claim 12, wherein the derivatizing is at a temperature of from about 4°C to about room temperature.

22. The method of claim 12, wherein the linking comprises exposing the linker to the enzyme after said derivatizing.

23. The method of claim 22, wherein the exposing is selected from a group consisting of allowing a solution comprising the enzyme to flow relative to the PSG, pumping a solution comprising the enzyme relative to the PSG, placing the PSG in a solution comprising the enzyme, and any combination thereof.

24. The method of claim 22, wherein the exposing is for a time of from about 30 minutes to about 24 hours.

25. The method of claim 22, wherein the exposing is at a temperature of from about 4°C to a higher temperature sufficient to avoid diminishment of the activity of the enzyme.

26. The method of claim 22, wherein the exposing is at a temperature of from about 4°C to about 40°C.

27. The method of claim 1, wherein the enzyme comprises an amine functional group.

28. The method of claim 1, wherein the enzyme is selected from a group consisting of trypsin, pepsin, chymotrypsin, malate dehydrogenase, citrate lyase, isocitrate dehydrogenase, and lactate dehydrogenase.

29. The method of claim 1, wherein the linking comprises linking different enzymes on the surface of the PSG.

30. The method of claim 1, wherein the linking is such that the enzyme is covalently linked to a surface in at least one pore of the PSG.

31. The method of claim 1, wherein an activity of the enzyme is enhanced when linked to the surface of the PSG relative to an activity of that enzyme when free of the surface of the PSG.

32. The method of claim 31, wherein the activity is enhanced up to about 200-fold.

33. A method comprising:
providing a photopolymerized sol-gel material (PSG);
linking an enzyme to a surface of the PSG via covalent linkage; and
after said linking, introducing a solution comprising a substrate to the surface of the PSG.

34. The method of claim 33, wherein the providing comprises providing a PSG that comprises a photopolymerized sol-gel material.

35. The method of claim 33, wherein the introducing is facilitated by pressure or voltage.

36. The method of claim 35, wherein the pressure is from about 0.5 to about 20 psi.

37. The method of claim 35, wherein the voltage is from about 1 kV to about 5 kV.

38. The method of claim 33, wherein the introducing is sufficient for the enzyme to at least partially digest the substrate.

39. The method of claim 33, wherein the introducing is for a time from about 5 seconds to that sufficient for at least partial digestion of the substrate.

40. The method of claim 33, wherein the introducing is for a time from about 5 seconds to about 60 minutes.

41. The method of claim 33, wherein the introducing is at a temperature from about 15°C to about 40°C.

42. The method of claim 33, wherein the substrate comprises a material having a diameter of about a nanometer or more.

43. The method of claim 33, wherein the substrate comprises a component of a biological material.

44. The method of claim 33, wherein the substrate is selected from a group consisting of a biomolecule, a protein, an oligonucleotide, a peptide, a steroid, an organic acid, and any combination thereof.

45. A method comprising:
providing a polymerized sol-gel material (PSG);
linking an enzyme to a surface of the PSG via covalent linkage;
after said linking, introducing a solution comprising a substrate to the surface of the PSG; and
after said introducing, separating any remaining substrate and any product of said introducing from the solution.

46. The method of claim 45, wherein the providing comprises providing a PSG that comprises a photopolymerized sol-gel material.

47. The method of claim 45, wherein the separating is facilitated by pressure or voltage.

48. The method of claim 47, wherein the voltage is from about 1 kV to about 30 kV.

49. The method of claim 45, wherein the separating is selected from a group consisting of chromatographic separation, electrophoretic separation, and any combination thereof.

50. The method of claim 45, further comprising, after said separating, detecting for any remaining substrate and any product of said introducing.

51. The method of claim 50, wherein the detecting is selected from a group consisting of absorption detection, spectroscopic detection, and any combination thereof.

52. A device comprising:
a polymerized sol-gel material (PSG); and
an enzyme covalently linked to a surface of the PSG.

53. The device of claim 52, wherein the PSG is disposed in a sub-device selected from a group consisting of a column, a pipet, a well, and a well plate.

54. The device of claim 53, wherein the sub-device is sufficient to separate an analyte from a sample.

55. The device of claim 52, wherein the PSG comprises a photopolymerized sol-gel material.

56. The device of claim 52, wherein the PSG comprises an inorganic PSG.

57. The device of claim 52, wherein the PSG comprises an organic-inorganic PSG.

58. The device of claim 52, wherein the PSG comprises a PSG prepared from a metalorganic material.

59. The device of claim 58, wherein the metalorganic material is a metal alkoxide.

60. The device of claim 52, wherein the PSG comprises a PSG prepared from a photoactive material selected from a group consisting of a metalorganic

material that comprises a photoactive group, an organic material that comprises a photoactive group, a photoinitiator, and any combination thereof.

61. The device of claim 52, wherein the PSG comprises a PSG prepared from a porogen material.

62. The device of claim 52, wherein the PSG comprises a PSG having at least one pore having a diameter in a range of about 0.5 microns to about 20 microns.

63. The device of claim 52, wherein the surface of the PSG is derivatized with a linker.

64. The device of claim 63, wherein the linker comprises a functional group that facilitates the linking of the linker to the surface of the PSG.

65. The device of claim 64, wherein the functional group is an alkoxy group.

66. The device of claim 63, wherein the linker comprises a functional group that facilitates the linking of the enzyme to the linker.

67. The device of claim 66, wherein the functional group is selected from a group consisting of an aldehyde functional group and a succinimide functional group.

68. The device of claim 63, wherein the linker comprises a silicate material.

69. The device of claim 63, wherein the linker comprises a trialkoxysilane.

70. The device of claim 63, wherein the enzyme is linked to the surface of the PSG via the linker.

71. The device of claim 52, wherein the enzyme comprises an amine functional group.

72. The device of claim 52, wherein the enzyme is selected from a group consisting of trypsin, pepsin, chymotrypsin, malate dehydrogenase, citrate lyase, isocitrate dehydrogenase, and lactate dehydrogenase.

73. The device of claim 52, wherein different enzymes are linked to the surface of the PSG.

74. The device of claim 52, wherein the linking is such that the enzyme is covalently linked to a surface in at least one pore of the PSG.

75. The device of claim 52, wherein an activity of the enzyme is enhanced when linked to the surface of the PSG relative to an activity of that enzyme free of the surface of the PSG.

76. The device of claim 75, wherein the activity is enhanced up to about 200-fold.

77. The device of claim 52, wherein the enzyme is sufficient to at least partially digest a substrate.

78. The device of claim 77, wherein the substrate comprises a material having a diameter of about a nanometer or more.

79. The device of claim 77, wherein the substrate comprises a component of a biological material.

80. The device of claim 77, wherein the substrate is selected from a group consisting of a biomolecule, a protein, an oligonucleotide, a peptide, a steroid, an organic acid, and any combination thereof.

81. The device of claim 77, further comprising a separation sub-device downstream of the linked-enzyme PSG, the separation sub-device sufficient to separate any remaining substrate and at least one product from the linked-enzyme PSG.

82. The device of claim 81, wherein the separation sub-device is sufficient to separate via any one of chromatographic separation, electrophoretic separation, and any combination thereof.

83. The device of claim 81, further comprising a detection sub-device downstream of the separation sub-device, the detection sub-device sufficient to detect any remaining substrate and at least one product from the separation sub-device.

84. The device of claim 83, wherein the detection sub-device is sufficient to detect via any one of absorption detection, spectroscopic detection, and any combination thereof.